International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD)
ISSN(P): 2249-6866; ISSN(E): 2249-7978
Vol. 7, Issue 3, Jun 2017, 9-16

TRANS STELLAR
•Journal Publications •Research Consultancy

INVESTIGATION ON MODIFIED BITUMENIOUS MIX USING HDPE, CRUMB RUBBER & COCONUT COIR

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ABSTRACT

Improper maintenance and increase in traffic load leads to deterioration of the roads. In India, the bitumen produced is not reaching the requirements of different weather conditions our country. Hence there is a need of rise to the modified bituminous mixes which improves the stability of the road structure. In this present study, an attempt is made to use the waste materials such as High Density Polyethylene (HDPE) crumb rubber and coir enhance the flexible pavement quality bitumen. These waste materials can be reused. They can mitigate the environmental problems and minimize the cost of construction of roads. In this investigation, we replaced bitumen with crumb rubber and HDPE at different proportions and lastly added coir for good tensile strength

KEYWORDS: Bitumen, Coconut Coir, HDPE (High Density Polyethylene), Crumb Rubber, Marshall Mix Design, Semi-Dense Bituminous Concrete & Stability and Flow

Received: Mar 20, 2017; **Accepted**: Apr 05, 2017; **Published**: Apr 26, 2017; **Paper Id**.: IJCSEIERDJUN20172

Original Article

INTRODUCTION

Highways in India are constructed using flexible pavement which is having a surface course with the bituminous concrete. Due to the lack of proper maintenance and shortage of fund cause a continuous deterioration of the road structure. Hence, to reduce this, we need to construct a bituminous concrete which should satisfy the requirements section 509 which specifies the construction of bituminous course for surface course of different grade for single and multiple layer thickness.

Flexible pavement generally, has a less flexure strength when compared to rigid pavement. Flexible pavement consists of the following component parts such as soil sub- grade, sub- base, base and surface course

Addition of polyethylene increases the stiffness and improves the temperature susceptibility of the bitumen. As the stiffness improve, rutting resistance of the mixture increases. Polymers have a number of important properties which exploited along or together make a Significance and expanding contribution to construction needs. HDPE modified binders shows an improved in bonding properties. During this investigation the use and the optimum percentage of HDPE in bituminous mix is carried out

Crumb rubber is a recycled rubber from automotive and truck scrap tires, which is having a good durability are taken. Hence, a study has been undertaken to utilize HDPE and crumb rubber to increase the strength of the bitumen mix of road construction

Objectives of the Project

- This study aimed at preparation of Gap –graded mix of bitumen and modified with crumb rubber, HDPE and to find the variation of conventional properties.
- Study the effect of adding polyethylene on the hot mix asphalt.
- To study the mechanical properties by adding the polyethylene to the bituminous mixes to achieve higher stability
- To find the optimum percentage of modified bituminous mix using HDPE, rubber and coir

LITERATURE REVIEW

Mohammad T (2007) had made a detailed investigation that the amount of HDPE was determined to be (6-18%) by weight of the optimum asphalt percent (5.4%), which equates to (0.34-1.03%) by weight of total aggregate. The optimum modified content was 12%, which is similar to 0.68% of the total aggregate weights. Hence, using HDPE in the bituminous mix reduces the pavement deformation and increases the resistance of the structure which decrease the flow and damage of the pavement

Nabin Rana Magar has investigated on the Performance of Crumb Rubber Modified Bitumen by Varying the Sizes of Crumb Rubber. In this investigation, 15% weight of crumb rubber of different sizes is used for modified bituminous mix design so as to obtain the size of crumb rubber which increases the stability and reduce the flow

Rokade S (2012) concluded that, The Marshal Stability Value increased from 8% to 10% Crumb Rubber and then it is decreased, i.e. 10% of Crumb Rubber of the weight of bitumen is the optimum dose. The bulk density shown an increase trend from 8% to 12%

EXPERIMENTAL WORK

Material Characterization

Aggregates

The coarse aggregate used was a normal weight aggregate with a maximum size of 10 mm and minimum size of 2.36mm as coarse aggregate, Stone dust was used as the filler.

Table 1: Material Characteristics of Aggregate

S. No.	Test	Morth Speciication	Test Values		Test Method
1.	Impact Value (%)	<30	28.84		IS 2386 Part IV
2.	Crushing value (%)	<30	25.45		IS 2386 Part IV
3.	Specific Gravity test	2.5-3	10mm Aggregate	2.71	IS 2386 Part III
			2.36mm Aggregate	2.67	
			Stone Dust	2.61	
4.	Water Absorption	<2	1.01		IS 2386 Part III

Figure 1: Coarse Aggregate

Figure 2: HDPE

Figure 3: Crumb Rubber

Bitumen

60/70 grade of bitumen is used as the binder and its properties as determined by standard test procedures are tabulated.

Table 2: Test on Bitumen

S. No.	Test	Permissible Values	Test Values	BIS Test Method
1.	Penetration value 25ºc	50-70	64	IS 1203- 1978
2.	Softening point, ºc	>50	57	IS 1205- 1978
3.	Ductility value at 27ºc, cm	>75	94	IS 1208- 1978
4.	Specific gravity	>0.99	0.9	IS 1202- 1978

CRUMB RUBBER

A Crumb rubber of locally available is considered which is passing through a 2.36 mm sieve, to reduce the voids and increases the durability of the pavement. The specific gravity of the rubber obtained by the test is 0.4

High Density Polyethylene

HDPE is used in this project work as plastics improves the ductility nature in bitumen which increases the stability. In this modified mix 0.5% of HDPE to the aggregates is added replacement with bitumen for better performance of flexible pavement

COIR

An untreated coir of the coconut is used which is available and the properties are similar to retted. An untreated coir bundle of 15mm was used in this investigation.

Proportioning of Aggregates

Semi Dense Bituminous Concrete

The properties of this modified bituminous mix are considered as a grade 1 semi dense bituminous concrete mix as per MoRTH specifications. This course is used for profile courses.

Table 3: Physical Requirements for Coarse Aggregate in Sdbc Grade 1

Property	Test	Value (%)
Cleanliness	Grain size Analysis	5 Max. Passing 0.075mm sieve
Strength	Aggregate Impact Value	27 Max.
Water absorption	Water absorption	2Max.
Stripping	Static Immersion Test	95 min. Retained coating

Table 4: Morth Specified Gradation for Aggregates in SDBC

IS Sieve in mm	Required %Passing	Upper Limit	Lower Limit	Average Value
13.2	90.100	100	90	95
9.5	70-90	90	70	80
4.75	38-51	51	35	43
2.36	24-39	39	24	31.5
1.18	15-30	30	15	22.5
0.3	9-19	19	9	14
0.075	3-8	8	3	5.5

The above table discusses on semi dense bituminous concrete single or double layer bituminous surface course. This above table describes the properties of aggregates used in semi dense bituminous mix grade 1 as per MoRTH specifications

Semi Dense Bituminous Grade 1 Mix Proportions

The following are the semi dense bituminous concrete mix as per MoRTH specifications. Considering

13.2 mm Aggregate: 60%

4.75 mm Aggregate: 20%

Stone Dust: 20%

Table 5: The Gradation of the Above Mix Proportion is given in Table

IS Sieve in mm	10mm	2.36mm	Dust	Proportioned Value	Required Value	Acceptable Range
13.2	100	100	100	100	95	90-100
9.5	73.3	100	100	89.32	80	70-90
4.75	1.2	100	100	60.48	43	35-51
2.36	0.5	16	100	30.8	31.5	24-39
1.18	1.5	1.7	75.2	19.60	22	15-30
0.3	0.5	1.3	49.6	13.06	14	9-19
0.075	0.5	0.8	15.6	4.38	5.5	3-8
Proportion (%)	60	20	20			

Preparation of Bituminous Mix

In the present study bituminous concrete gradation was used following specifications stated in MORT & H table 500-19. Three specimens of Marshall molds and one loose mix (uncompacted) are prepared for each size of crumb rubber. Aggregates are oven dried and sieved according to BC gradation and separated

Preparation

The bitumen are heated to a temperature of 121ºC to 125ºC with the first trial (nominal) percentage of bitumen 5.0% by weight of the aggregates to the heated aggregates and thoroughly mixed at temperature of 154ºC to 160ºC. The mix is placed in a preheated mold and compacted by a reamer with 75 blows on either side. Mixed aggregates are all weighed for the preparation of the specimen and compacted thoroughly to obtain the required thickness. Repeat the experiment by varying the proportions of rubber, hdpe and coir.

Note: Here, first bitumen are replaced by different proportions of rubber i.e. 0.5%, 1% & 1.5%. Highest strength was obtained for 1.5% rubber replaced mix. So 0.5% HDPE was replaced for that mix, further replacement was not possible as bitumen content was decreasing. Hence, the replacement was stopped there and 0.3% coir was added.

Figure 4: Sequential Step by Step Process of Bituminous Mix Mold

EXPERIMENTAL RESULTS

The Marshall stability test is used for the bituminous mix design as per Indian (MoRTH) recommendation

Principle of Marshall Method

It's similar to unconfined compression test where the load is applied to the specimen gradually. It provides the performance measure for the mix design. This test measures the maximum load support by the test specimen at a loading rate of 50.88mm/min in terms of stability

In this test along with the stability we are determining the density, void percentages filled with bitumen and in mineral aggregates for different mixes of modified bituminous

Table 6: Marshall Stability Test Results

S. No	Proportions	Molds	Stability	Avg. Stability
1	Nominal	1	18.6	18.2
		2	18.3	
		3	17.7	
2	0.5%rubber+4.5%bitumen	1	21.6	20.6
		2	20.4	
		3	19.8	
3	1%rubber+4%bitumen	1	22	21.4
		2	21.4	
		3	20.8	
4	1.5%rubber+3.5%bitumen	1	22.4	22.6
		2	21.8	
		3	23.6	
5	1.5%rubber+0.5%HDPE+3%bitumen	1	32	28.4
		2	27	
		3	26.2	
6	1.5%rubber+.5%HDPE+3%bitumen+0.3%coir	1	24.6	20.5
		2	17.6	
		3	19.4	

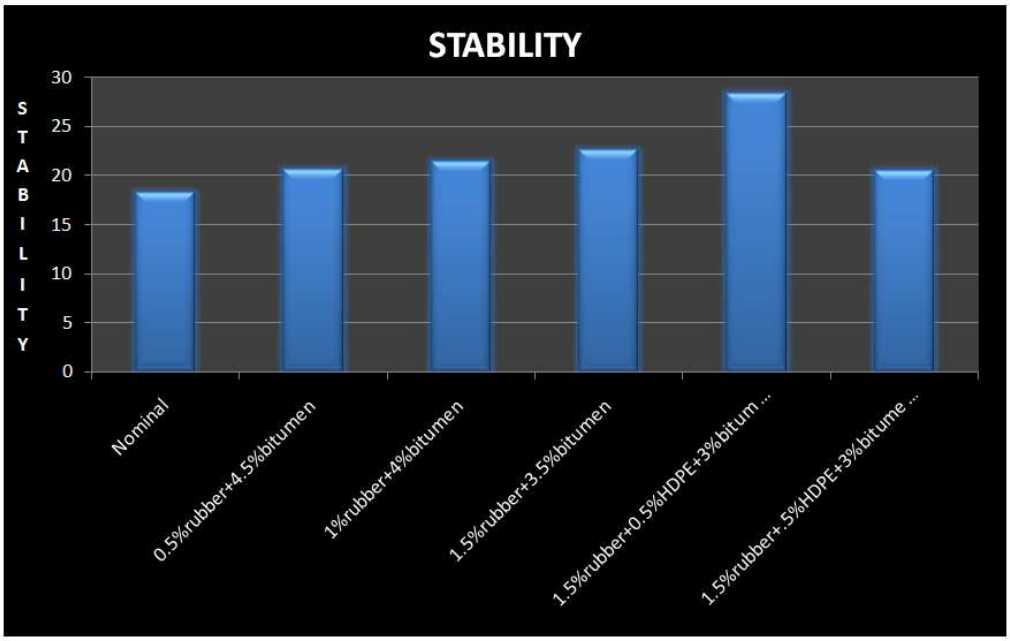

Figure 5: Stability of Different Mixes

Table 7: Marshall Stability Test Results

S. No	Proportions	Air Voids Percent VA	Voids in Mineral Aggregate Vma	Voids Filled with Bitumen Vfb
1	Nominal	6.47	18.11	64.30
2	0.5%rubber+4.5%bitumen	4.83	16.8	70.83
3	1%rubber+4%bitumen	3.62	15.5	76.5
4	1.5%rubber+3.5%bitumen	4.5	16.1	72.67
5	1.5%rubber+3%bitumen+0.5%HDPE	3.5	15.32	77.02
6	1.5%rubber+3%bitumen+0.5%HDPE+0.3%coir	3.21	15.03	78.64

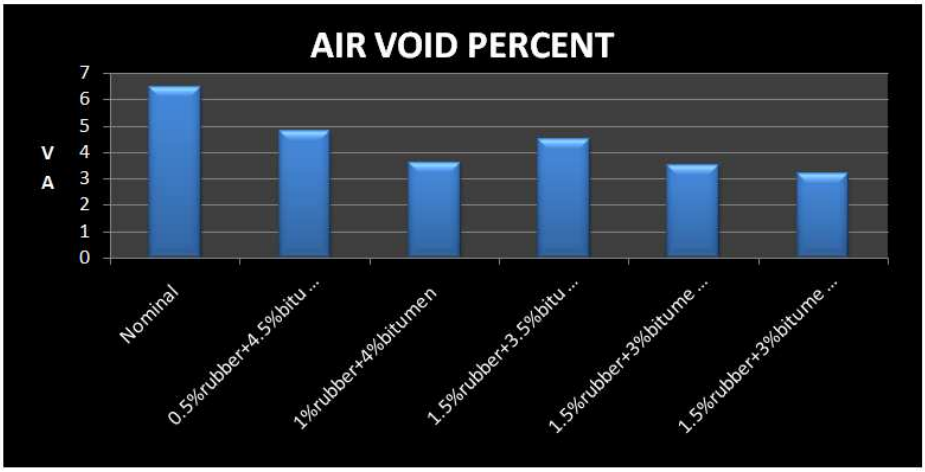

Figure 6: Air Void Percentage Vs Different Mix Proportions

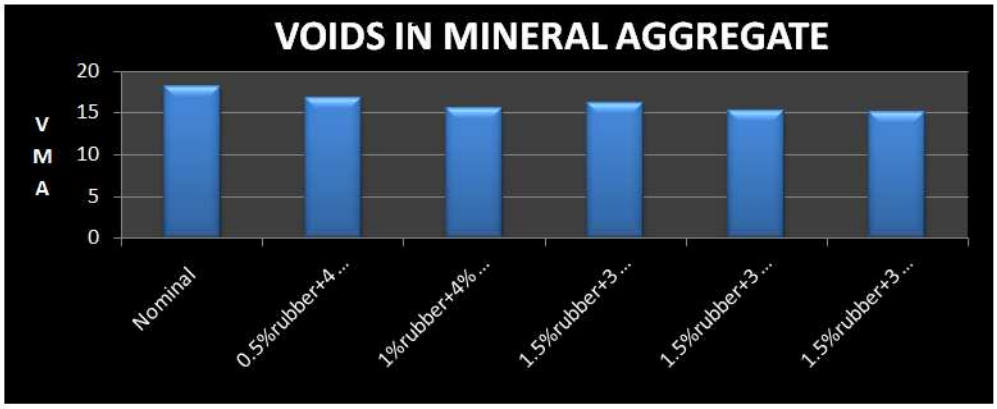

Figure 7:VMA Vs Different Mix Proportions

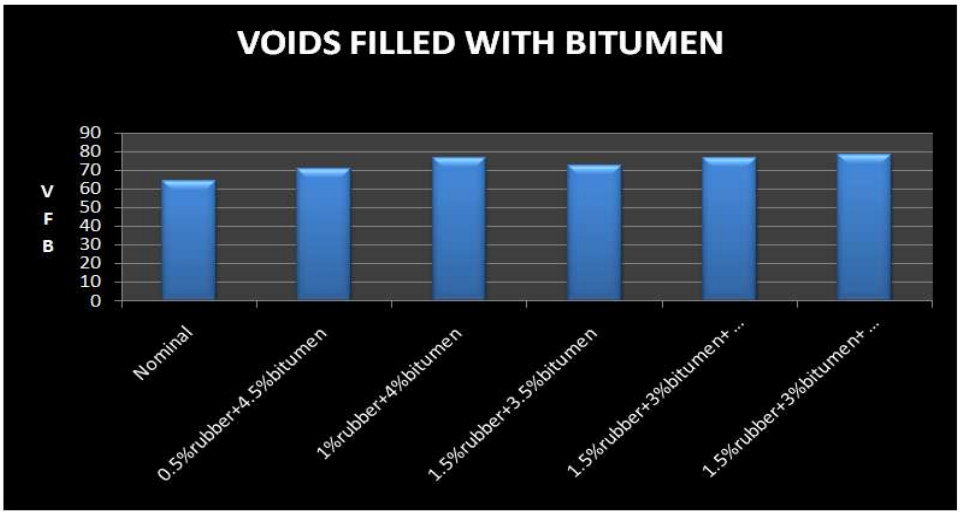

Figure 8:VFB Vs Different Mix Proportions

From the above table 5and figure 6,7,8 it is observed that 5% bitumen with 1.5% rubber+0. 5% HDPE+3% bitumen has achieved an increase in the stability compared to conventional mix. The results of the study indicated that the modified mixture has a higher stability. This would positively influence the rutting resistance of these mixtures

CONCLUSIONS

- Per above experimental test results on plain bitumen and crumb rubber modified bitumen, it is concluded that the penetration values and softening points of plain bitumen can be improved significantly by modifying it with the addition of crumb rubber which is a major environmental pollutant.
- Addition of rubber, HDPE to the bituminous mix increases the performance and stability when compared to the nominal mix. Hence, the modified mix is more stable for the traffic load.
- Addition coir to the rubber and HDPE mix their a decrease in stability when compared to the optimum modified mix
- The strength and void parameters of the rubber and the HDPE bituminous mix also satisfy the requirements of Specifications for Road and Bridge Works, MoRTH.
- The addition of 1.5%rubbe, 0.5%HDPE 0.3% is found to be the optimum fiber content in SDBC
- The Marshall Stability value of SDBC with optimum fiber content was found to be 2.4 KN
- Keeping in view the extinction of crude oil and increase in waste HDPE and crumb rubber, we made an attempt to replace bitumen with waste plastic and crumb rubber. The strength of the specimen is increased when it is replaced with crumb rubber and HDPE. Therefore, it is economical and durable.

ACKNOWLEDGMENT

The authors wish to thank Prof. Syed Eashan Adil, HOD of civil department, Aurora Engineering College for his kind support, valuable guidance and providing all facilities for conducting this experiment

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